



F-35 Lightning II

ASETS Defense 2009

Replacing Cu-Be Bushings



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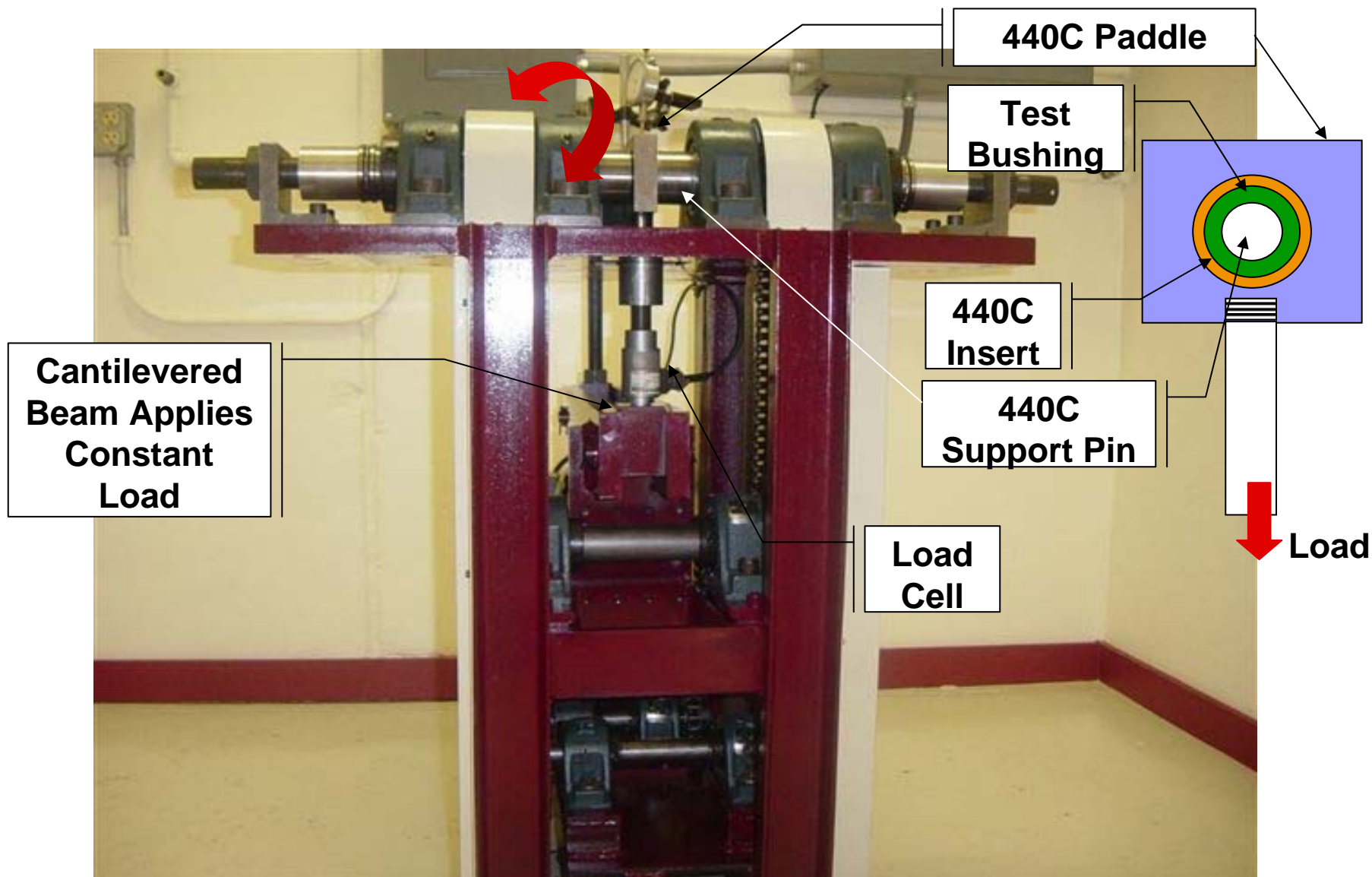


Timeline

- **2003-LM Hazardous Materials Management Program made Copper-Beryllium (Cu-Be) plain bearings (bushings) Restricted Materials**
 - *Any new LM designs have to investigate/implement alts*
 - *F-35 granted continued use while alternatives investigated/implemented to replace ~350 bushings*
 - *F-35 Static/Fatigue/Durability Test Articles immediately changed*
- **2004 – Five phase test series and Collaborative MAI**
 - *Toughmet AT/TS and Nitronic 60 CW initial promising candidates*
 - *Found Mil-B-81820 Navy Bushing Qualification testing rig in San Antonio*
- **2005 - Based on initial test series, F-35 changed all <2.5"OD airframe bushings to Nitronic 60CW to new LM specification**
 - *Continued testing on biomedical Cobalt-Chrome-Moly alloy based on outstanding bushing test rig results*
- **2006 – Completed initial and enhanced test series, direction to continue development of BioDur CCM as a wrought aerospace qualified material**
 - *Far superior wear properties and comparable strength*



Mil-B-81820 Qual Test Rig





Sub Scale Bushing Test



- **COMPONENTS**

- *BUSHING - press fit; candidate material*
- *PIN - slip fit; MP 35N steel (pictured) and 440C steel*

- **LOAD**

- *normal to bushing ID / pin OD interface*
- *+ / - 25 degrees steady rotation while under load*
- *starts at 2000 pounds (all loads are actual); increases 500 pounds every 100 cycles; max is 10,000 pounds reached at 1600 cycles; run-out at 2000 cycles*



Sub Scale Bushing Test Cont'd



- **RESULTS**

- *The following specimens (pictures on next pages) all reached 10,000 pounds at 1600 cycles, but only one material would continue to 'run-out'.*
- *CCM showed no negative signs at run-out so load and cycles were increased; failure did not occur.*
- *Higher performance for all candidate materials was seen when using 440C pins due to less spalling and galling.*

- **DISCUSSION**

- *Both Nit 60 and CCM performed excessively better than Cu-Be even though both have less compressive yield strength than Cu-Be. Different grades (strengths) of the same material showed very little performance differences. For 'wear' applications tribology is far more important than strength as long as the compressive yield strength is not exceeded.*



Sub Scale Bushing Test Cont'd



Cu-Be Bushing; MP 35N Pin

1725 cycles total

125 cycles at 10,000 lbs



ToughMet 3TS Bushing; MP 35N Pin

1600 cycles total

Stopped at one cycle of 10,000 lbs



Sub Scale Bushing Test Cont'd



CW Nitronic 60 Bushing; MP 35N Pin
1850 cycles total
250 cycles at 10,000 lbs



CCM Bushing; MP 35N Pin - *After run-out, ran at 12,000 pounds (2000 additional pounds) to 5000 cycles without failure. There was minimal (0.004-0.005") wear.*



Current CCM Status



- **Carpenter Alloy finalized alloy content for wrought material to new name ACUBE100**
- **Match Cu-BeTF00 properties**
 - *Will not match the more rarely used TH04 but still superior wear*
- **Verification complete up to 4"**
- **Qualification billets fabricated and waiting approved plan**
- **Gradual implementation including replacing Nitronic 60CW on an as-touched basis**



Lightning II



Questions?